PHOSPHORUS BASICS

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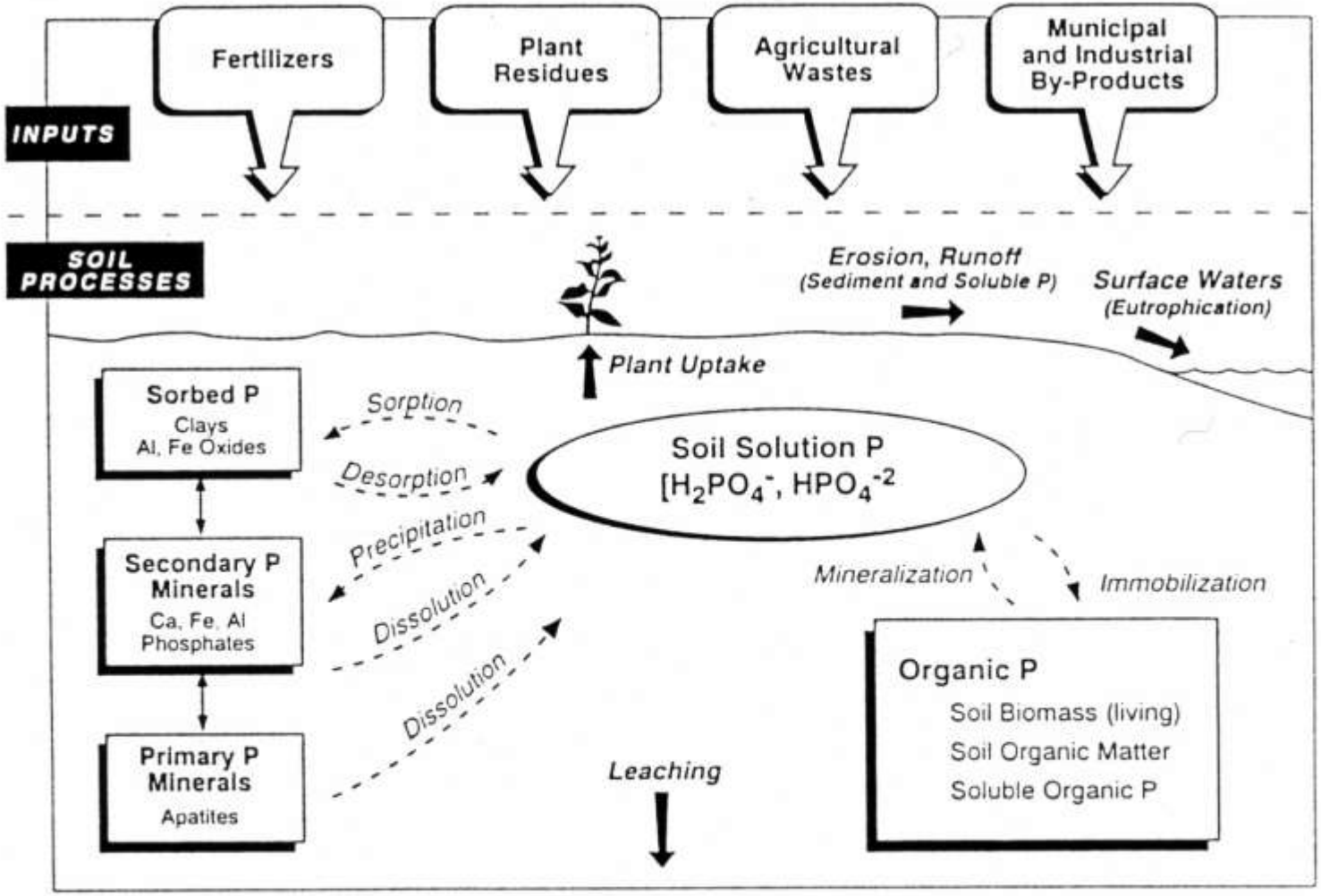
Phosphorus Terminology

- Phosphorus (P) = element name and symbol
- P_2O_5 = phosphate (oxide)
  - ✓Amount of P in fertilizers
  - ✓Rate of P to apply in recommendations
  - ✓Lb P_2O_5/acre
- $H_2PO_4^-$, HPO_4^{2-} = ionic forms of P that plants use

Forms & Concentrations of Phosphorus (P) in Soils

Form	Concentration (ppm)
Total	1000
Soil test P (available)	20-50
Soil solution	0.01-0.30



The Soil Phosphorus Cycle. (Pierzynski et al., 1994)

Adsorption and Desorption of Phosphorus

- Adsorption: removal of ionic P ($H_2PO_4^-$, HPO_4^{2-}) from solution by reaction with solid phase of soil.
- Solid phase: clays, oxides or hydroxides of Fe and Al, calcium carbonates, organic matter.
- Desorption (labile P): Portion of adsorbed P available for plant uptake, extraction, or measured by soil test.

Phosphorus (P) Reactions in Soils

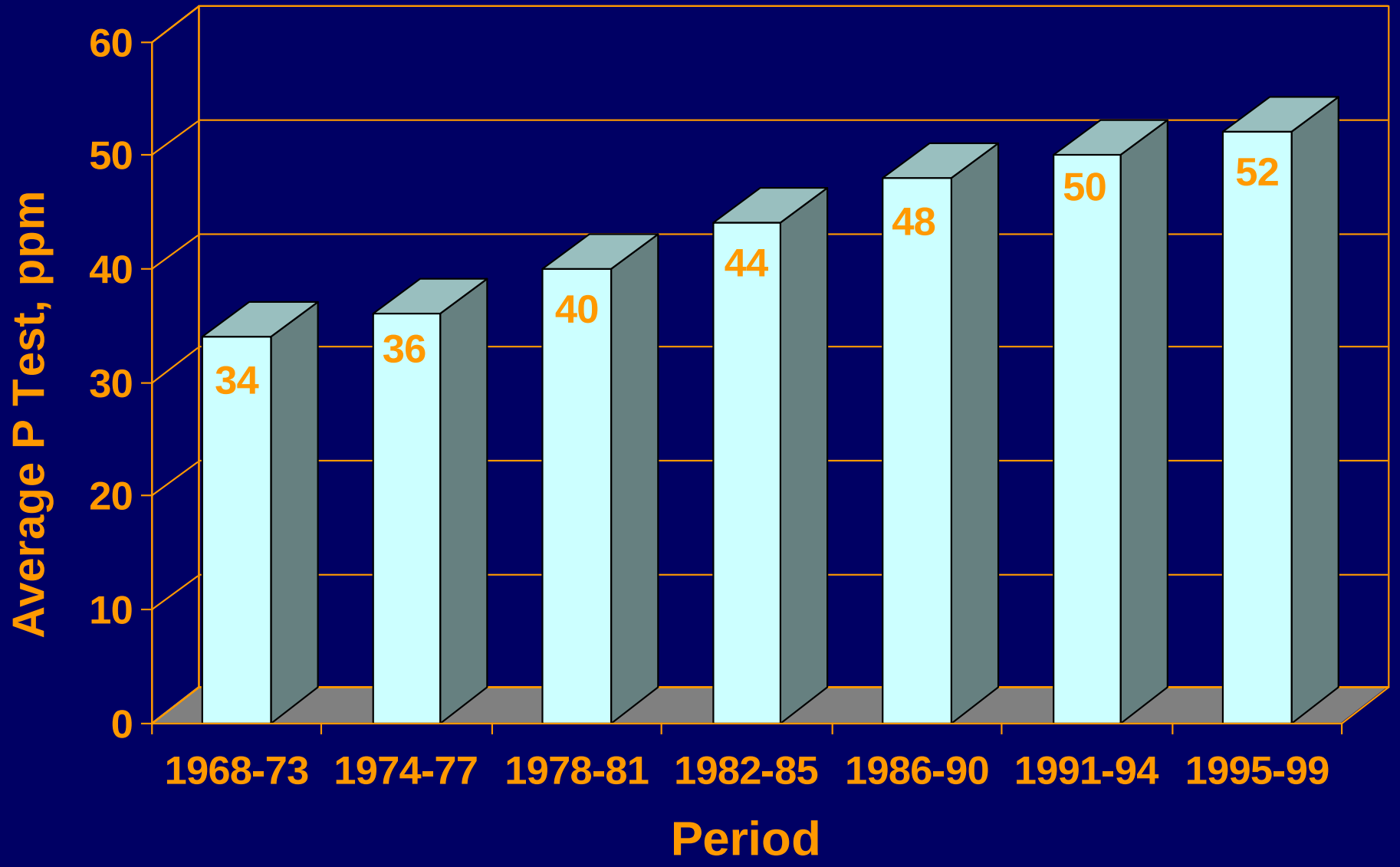
- Soluble P additions (fertilizers) react quickly to form slowly soluble compounds:
  - Sorbed P
    - Clays
    - Al and Fe oxides
  - Secondary P minerals (precipitation/dissolution)
    - Ca, Fe, Al phosphates

Interpreting Soil P Tests

	Soil test P, ppm	
Crop	Optimum	No response
Alfalfa	18-25	>35
Corn	15-20	>30
Soybean	10-15	>20

Medium and fine-textured soils, Bray P-1 test

Average Soil Test P in Wisconsin



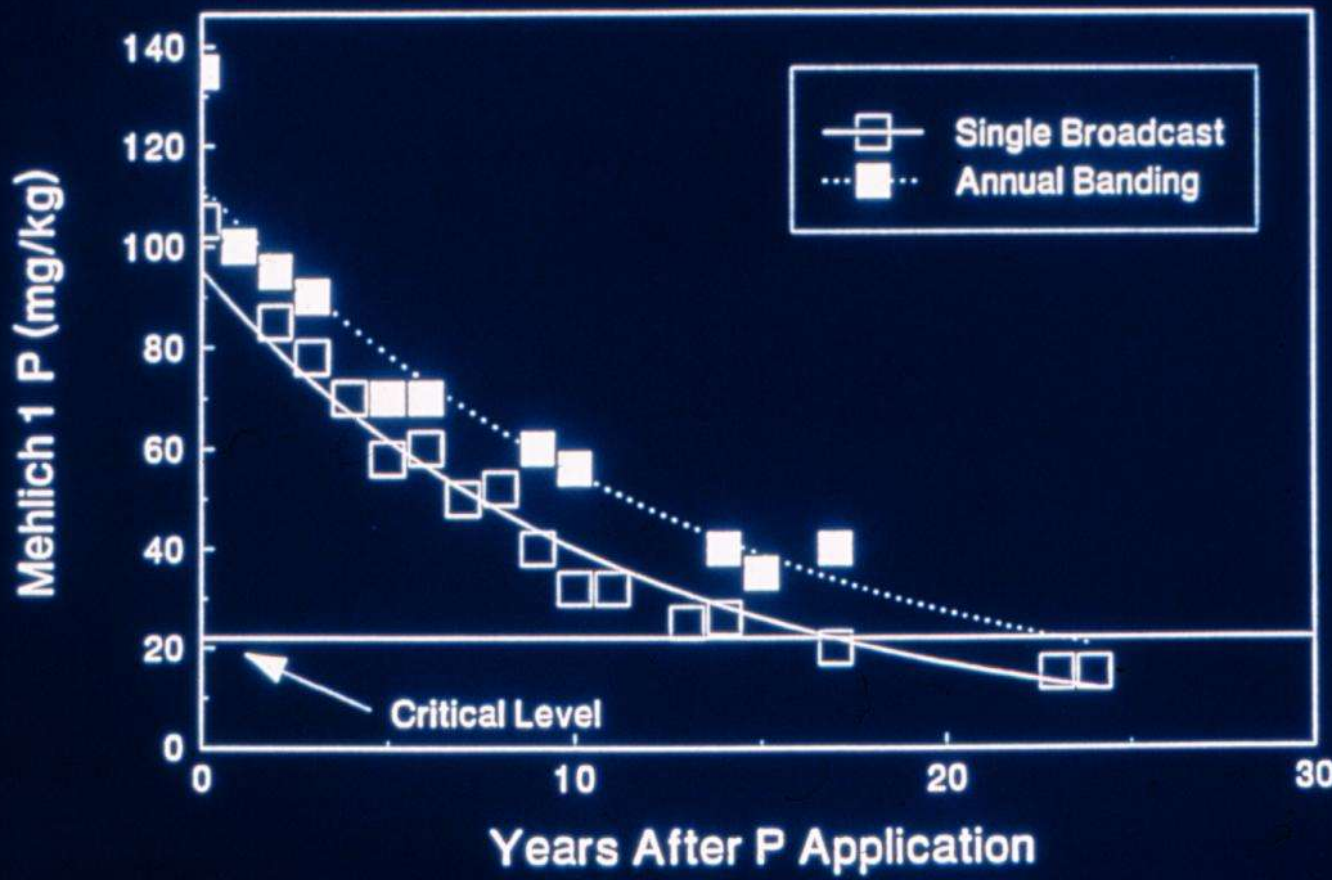
SOIL PHOSPHORUS BUFFERING CAPACITY

- Soil test P changes slowly with P additions or removals.
- Ave. 18 lb. P_2O_5/acre needed to change P test by 1 ppm

Soil Test P Changes Slowly

- Example:
  - Soil P test = 100 ppm = EH
  - Optimum soil test = 20 ppm
  - Removal needed for EH to Opt. = 18 lb P_2O_5/acre x 80 ppm = 1440 lb P_2O_5
  - Corn grain removes 60 lb P_2O_5/acre/year
  - 1440/60 = 24 yrs with no added P for EH change to optimum.

Decrease in soil test P in a corn-soybean rotation for 26 years. (McCollum, 1991)

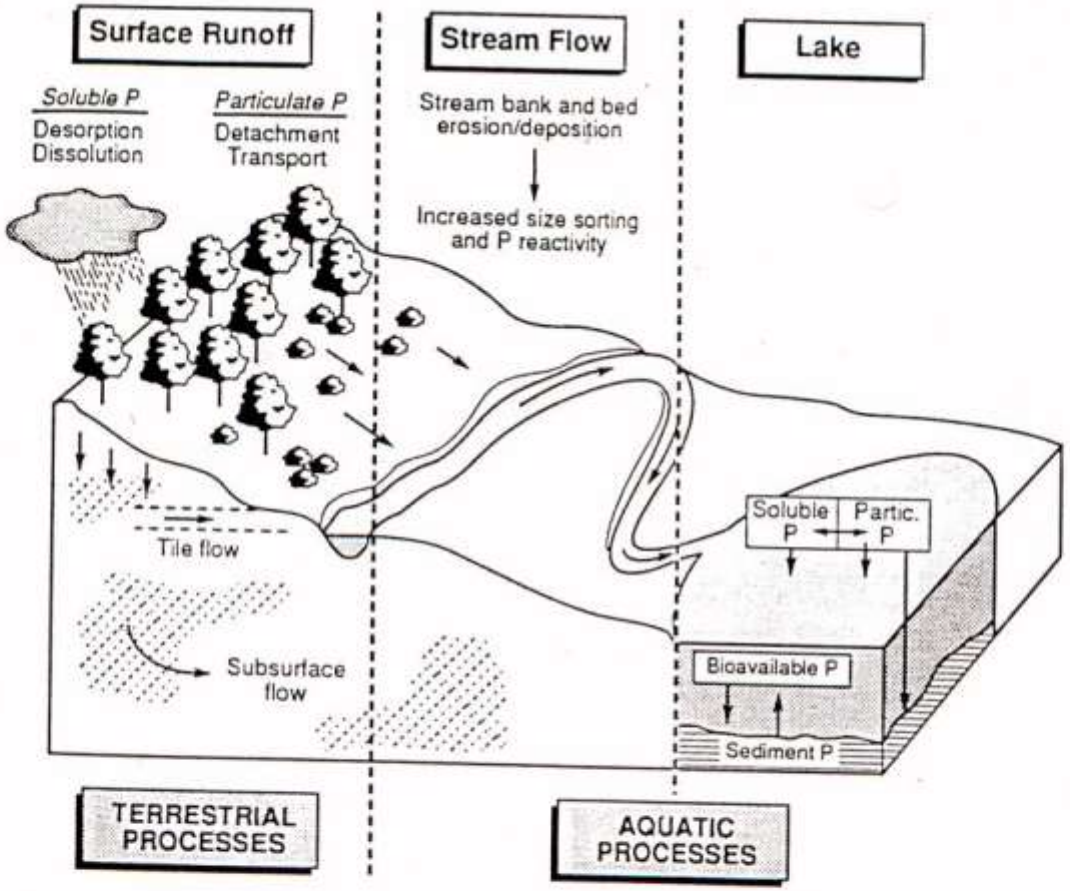


Relationship between P soil test and phosphorus fertilizer recommendation

Soil Test	Recommendation
Low, very low	Crop removal +
Optimum	Crop removal
High	½ Crop removal
Excessively High	None

PHOSPHORUS AND WATER QUALITY

- Phosphorus additions to natural waters can stimulate weed and algae growth.
- Vegetative growth and oxygen depletion reduce water quality.
- Phosphorus losses from agriculture can be a major source of P entering lakes and streams.



Phosphorus Transport and Fate in Ecosystems. (Pierzynski et al., 1994)

Phosphorus (P) Loss Processes

- In surface runoff:
  - Soluble (dissolved) P
  - Particulate P (soil particles)

- By leaching
  - Does phosphorus leach?

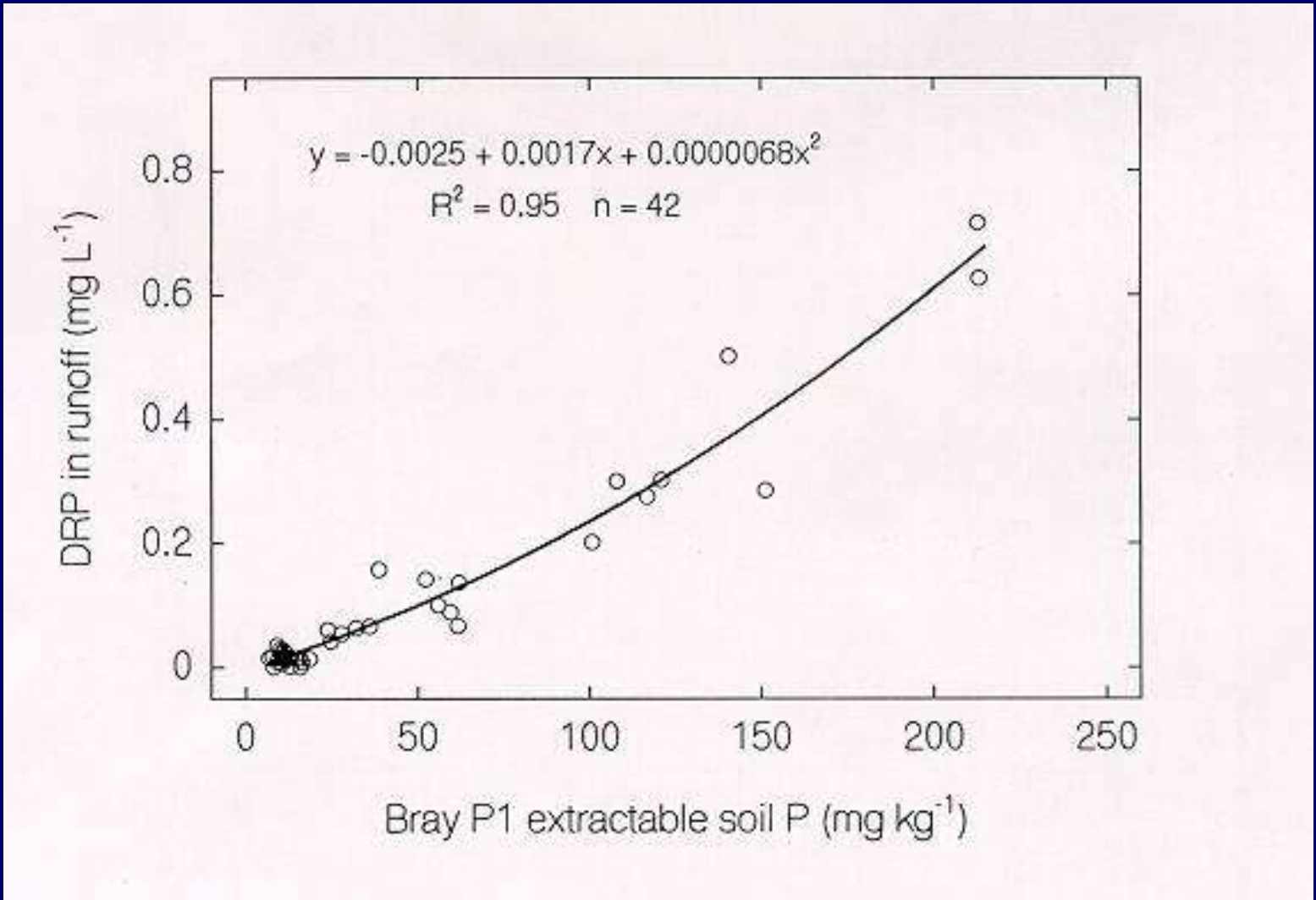
PHOSPHORUS (P) IN RUNOFF

- Dissolved (soluble P) (DP)
- Total P (TP)
- Particulate P (PP)
- Bioavailable P (BAP)
  - ✓DP + part of PP
- Bioavailable particulate P (BPP)
  - ✓BAP – DP = BPP

Critical Phosphorus Concentrations for Surface Waters

Type of water	Form of P	P conc. (ppm)
Lakes	Soluble P	0.01
Streams	Total P	0.10
Lakes	Total P	0.05

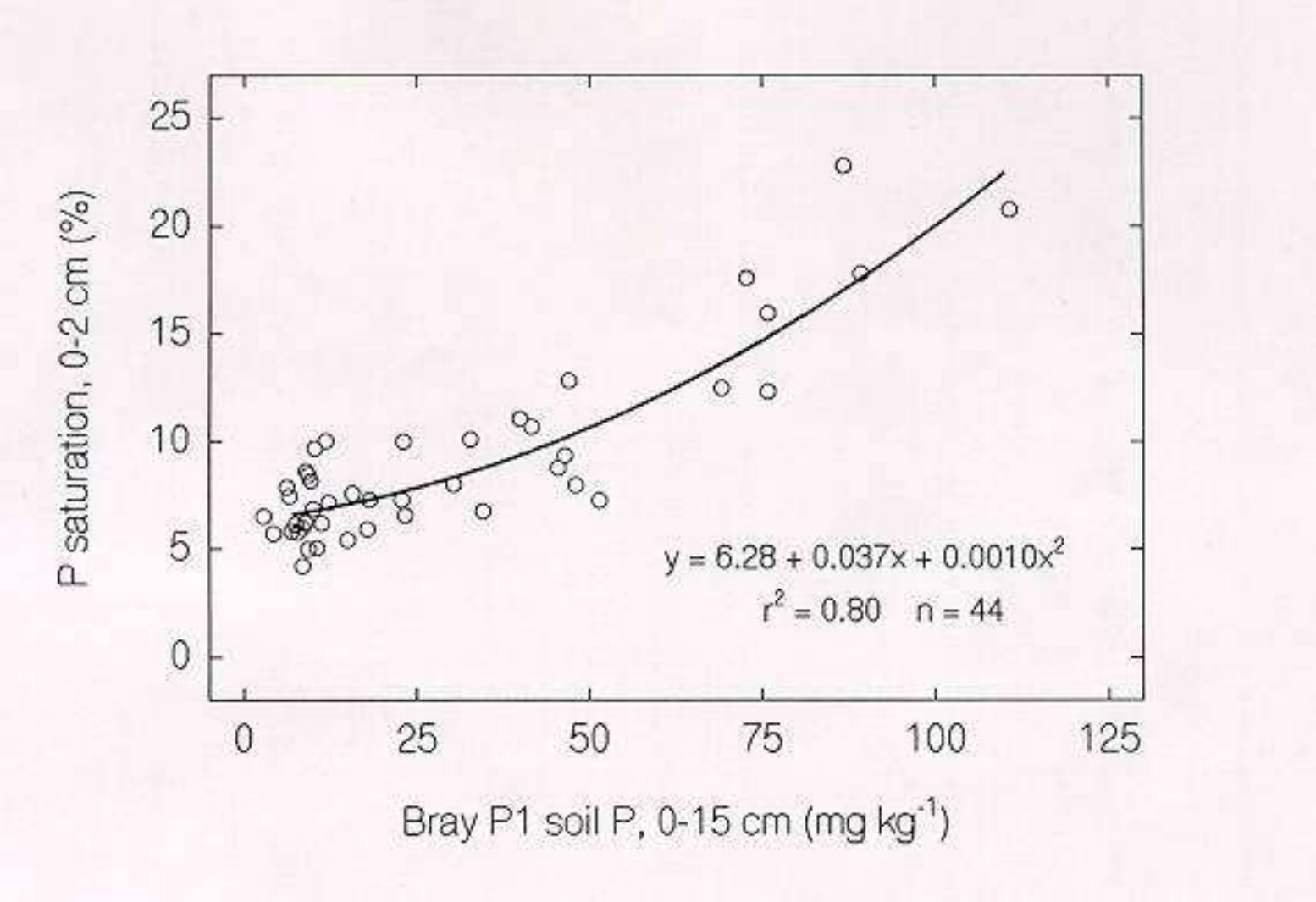
Relationship between Bray P-1 (0-2 cm) and DRP in runoff.



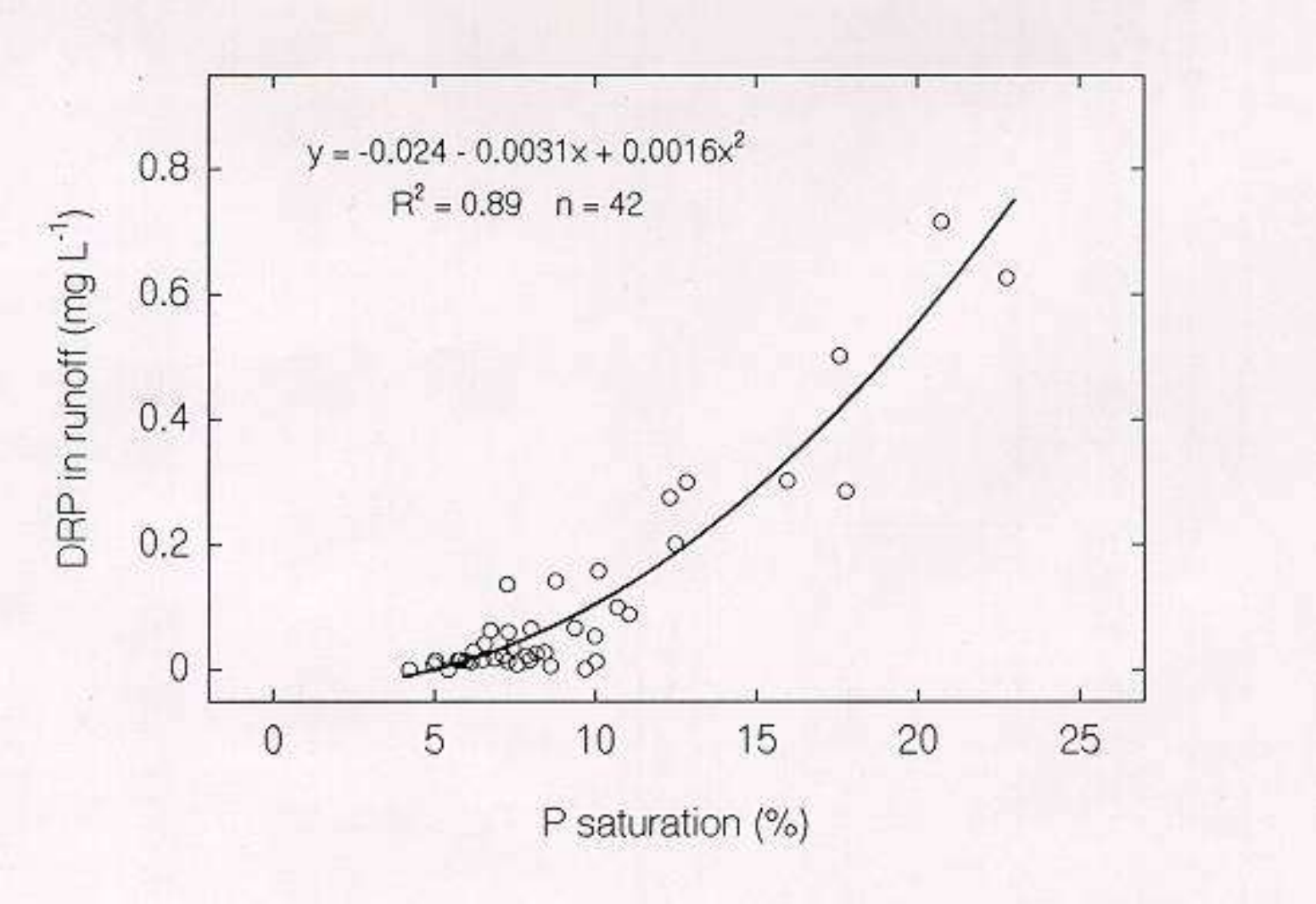
Phosphorus Saturation Percentage

- Method of measuring the soil's ability to hold P
- Indicates the % of the soil's P holding capacity that is occupied
- Netherlands work indicates that 25% saturation is the threshold or critical value for unacceptable P loss

Relationship between Bray P-1 extractable soil P (0-15 cm) and soil P saturation (0-2 cm).



Relationship between soil P saturation (0-2 cm) and DRP in runoff.



Phosphorus Leaching

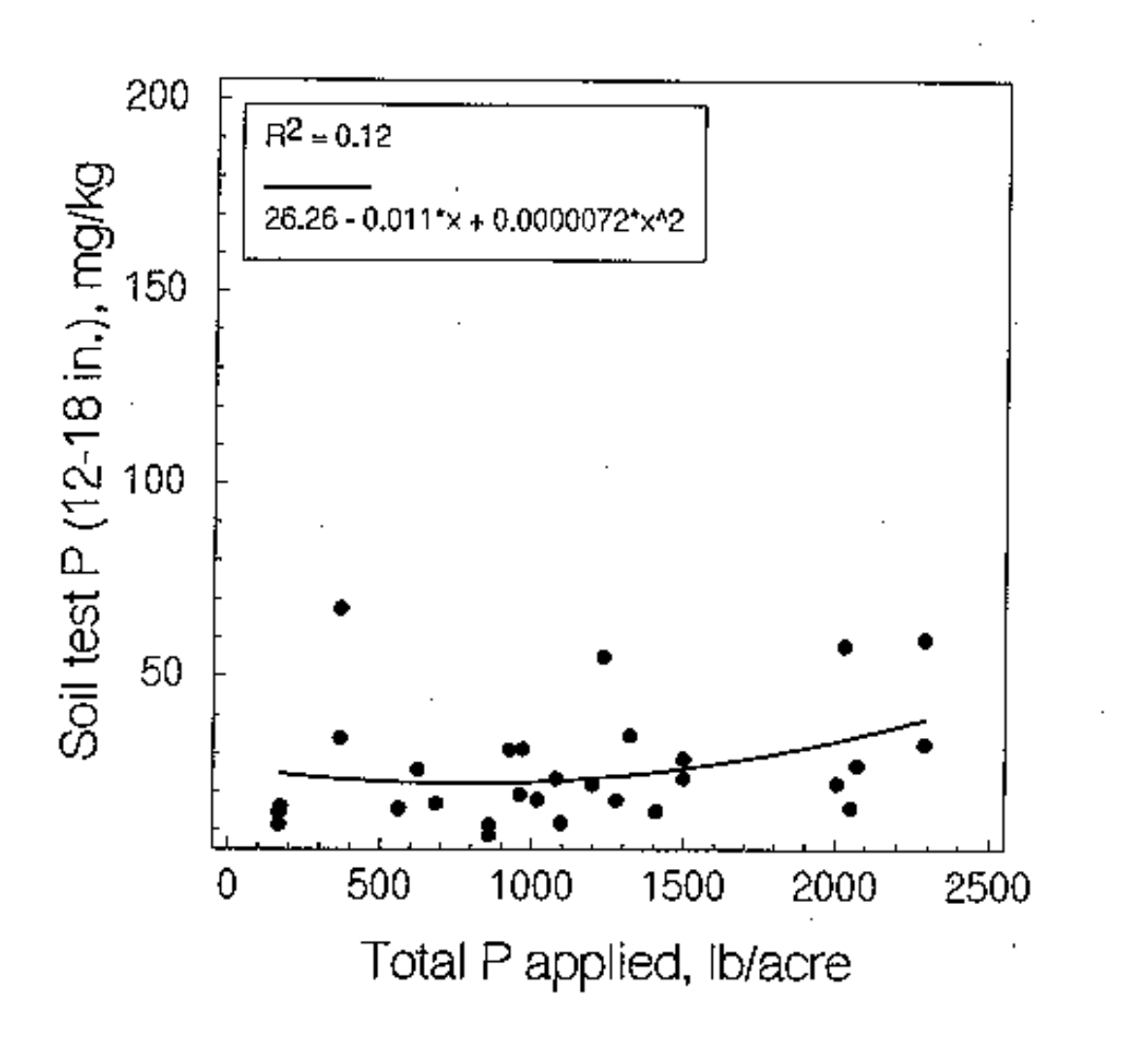
Soil phosphorus levels in 29 fields with various biosolids application histories, Madison, WI 1999.

Parameter	Range
Years of application	1979 – 1998
No. of applications	1 – 17
Total P applied (lb/a)	167 – 2288

Soil test P values at various soil depths, biosolids survey, Madison, WI, 1999.

Soil depth (inches)	Range of Bray-1 P (ppm)
0 – 1	31 – 198
0 – 6	27 – 201
6 – 12	11 – 168
12 – 18	9 – 67
18 – 24	4 – 67
24 – 36	12 – 63

Biosolids P rate effect on soil test P (12-18 in.), Madison, WI, 1999.



Phosphorus leaching in a prairie and in corn production at Arlington, Wis., 1998-2000.

System	Soil test P	Soluble P in leachate	
		Concentration	Load
	ppm	ppm	lb/acre
Prairie	25	0.02	0.04
No-till corn	80	0.09	0.42
Chisel plow corn	90	0.05	0.38

Leachate collected in pan lysimeters at 5 ft depth.

Brye et al. (2001)

Critical Phosphorus Concentrations for Surface Waters

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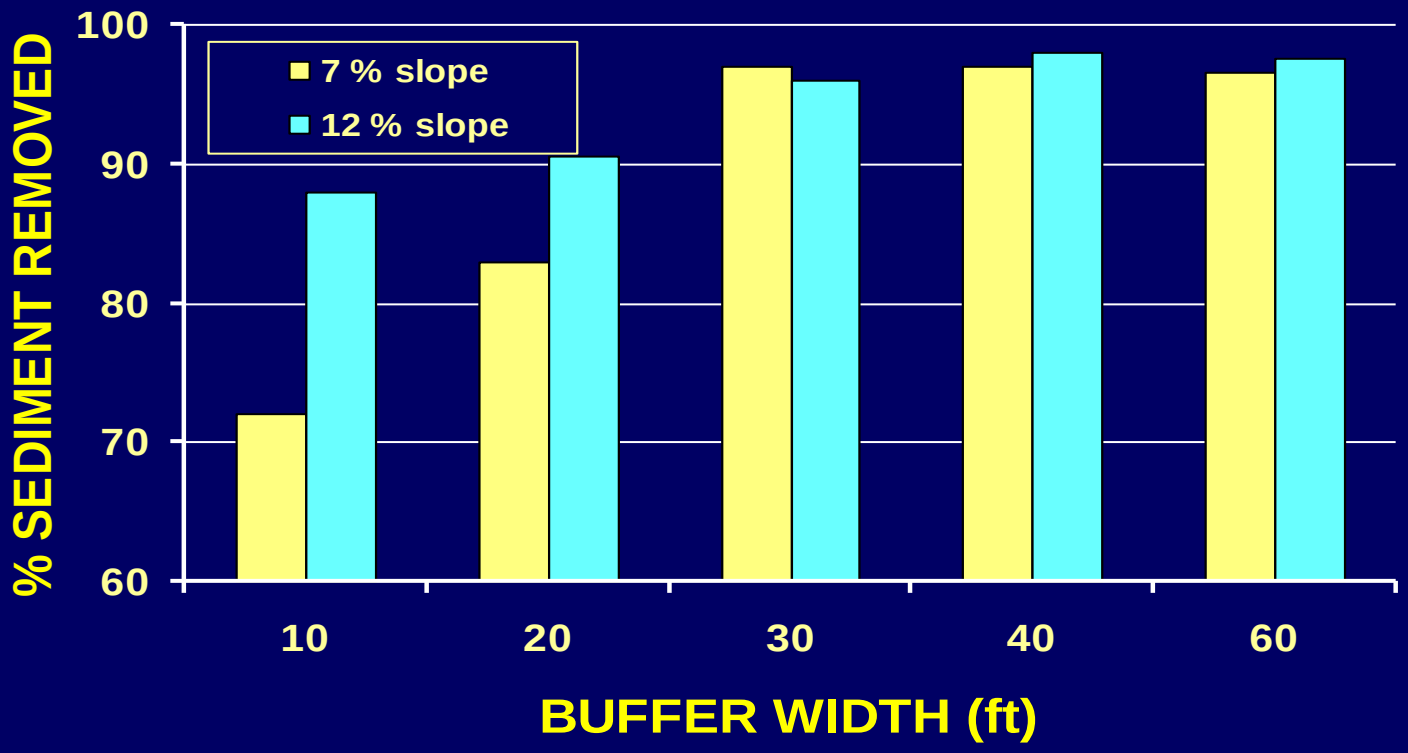
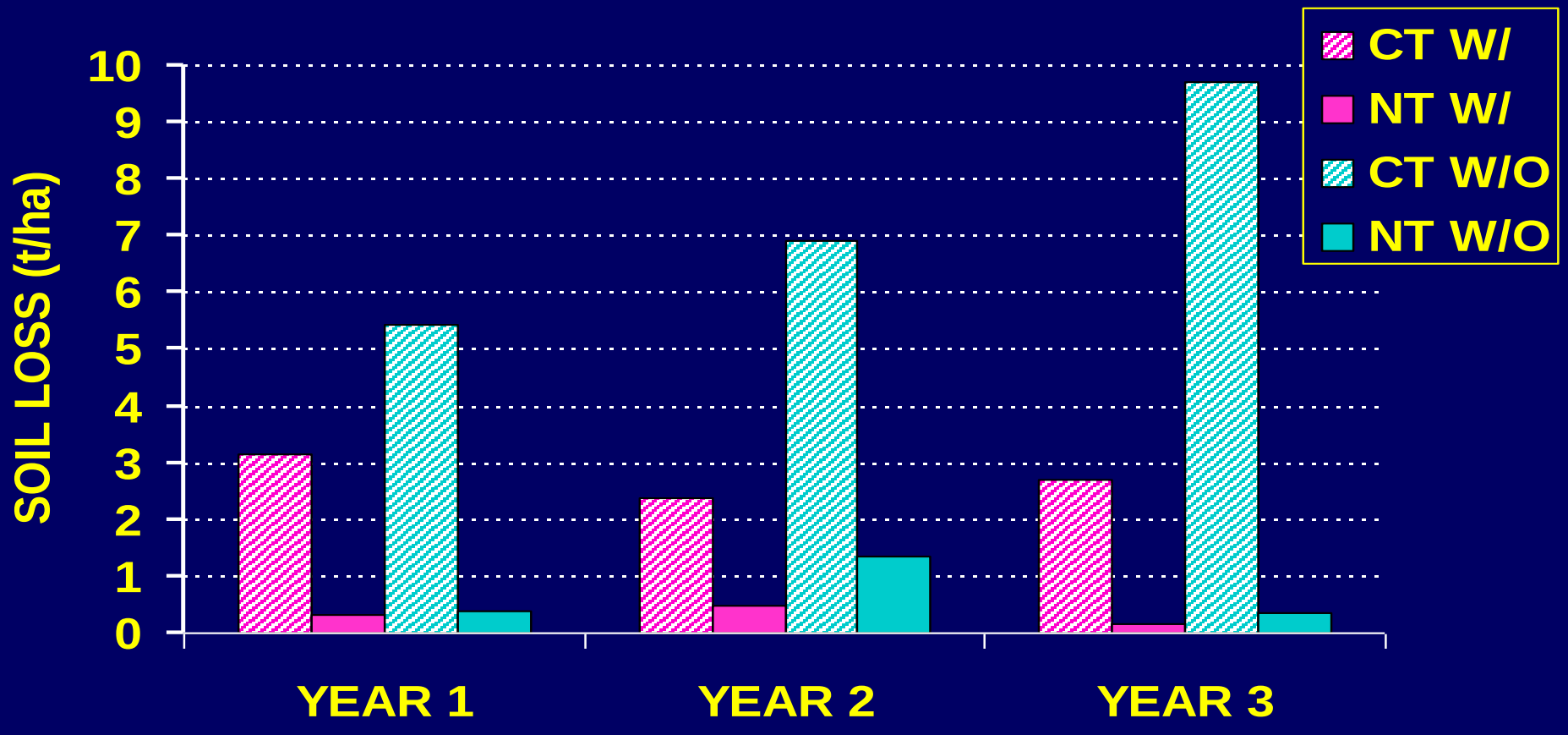
EFFECT OF BUFFER WIDTH AND SLOPE ON SEDIMENT DEPOSITION



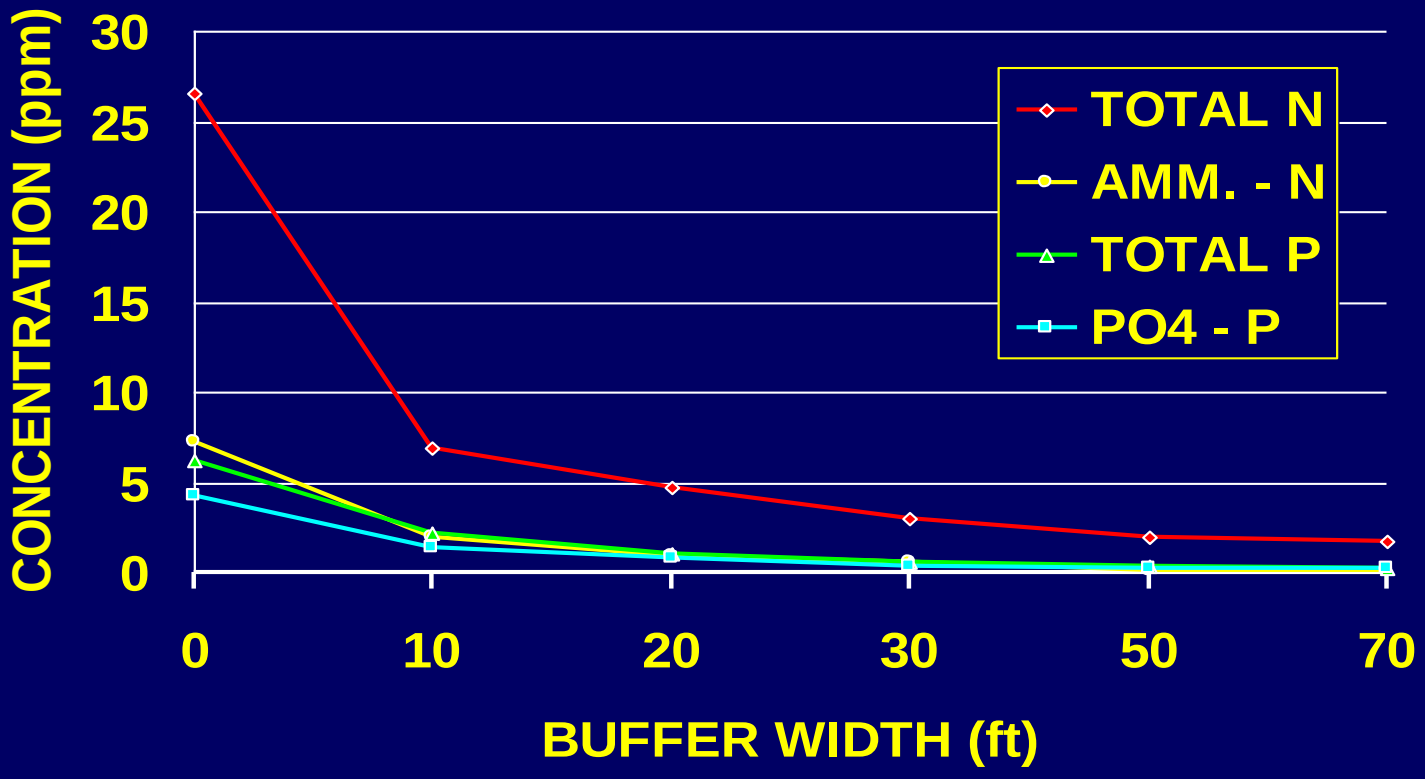
Smith, 1992

REDUCTION OF SOIL LOSS BY A 2-FT. GRASS BUFFER



Raffaele, et al., 1996

BUFFER EFFECT ON NUTRIENT REMOVAL FOLLOWING MANURE APPLICATION



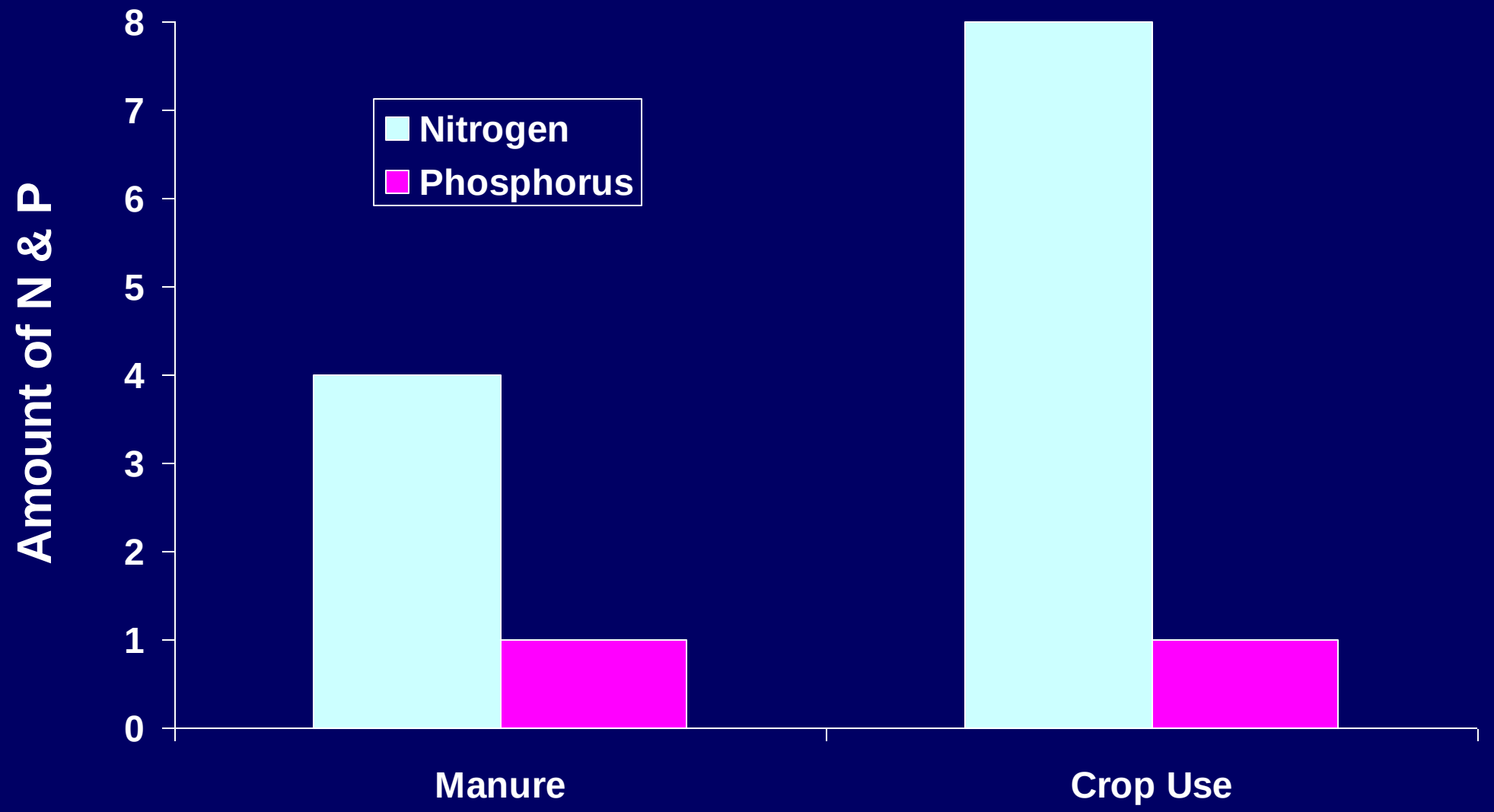
Chaubey et al., 1995

MANURE AND PHOSPHORUS ISSUES

What is the Manure-Phosphorus Problem?

- P accumulates in soils where manure is applied frequently to provide crop N requirement
- Phosphorus additions exceed crop P removals
- Ratio of N to P in manure = about 4:1
- Ratio of N to P in crops = about 8:1

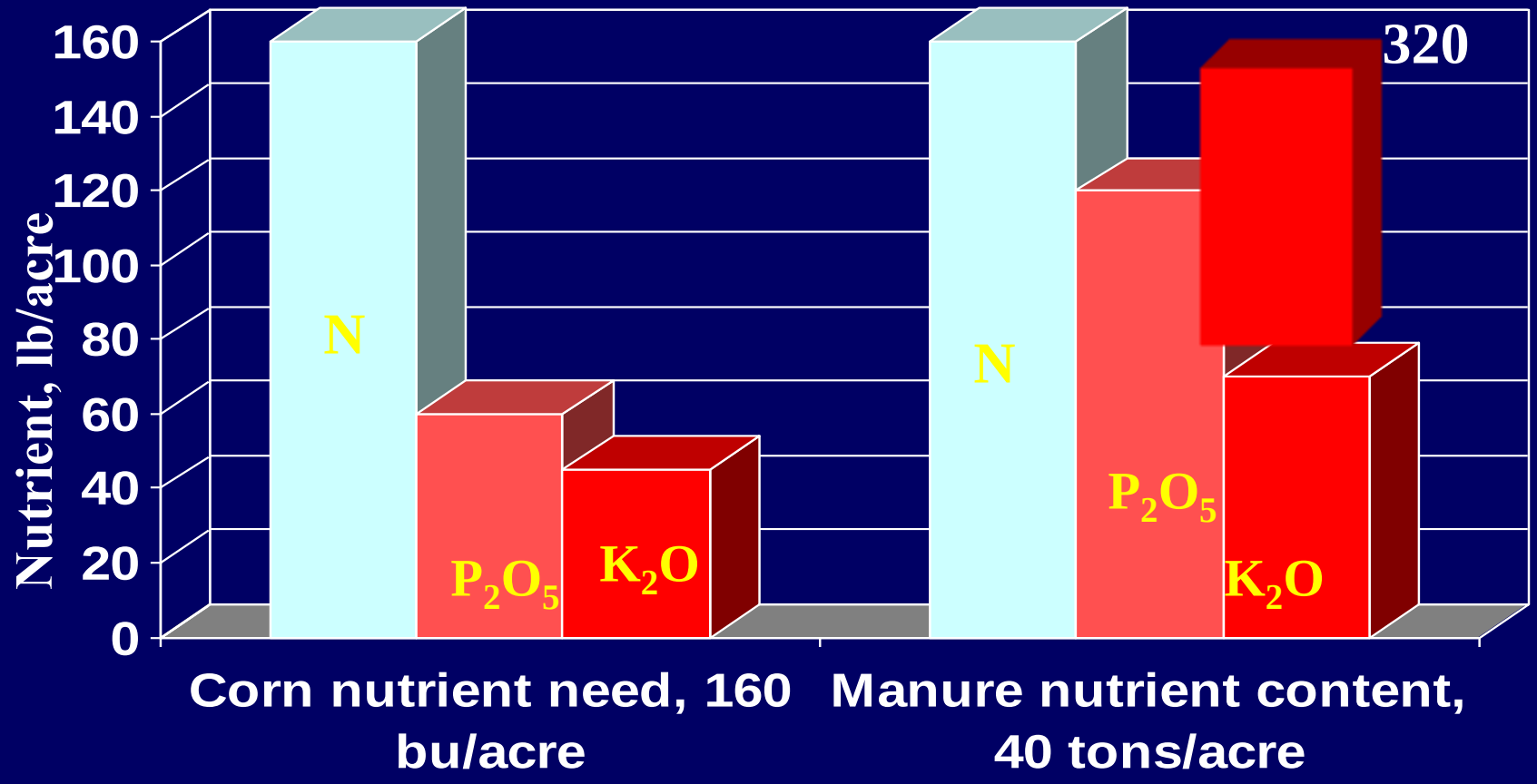
Relative amount of nitrogen and phosphorus in manure and used by crops



Ratio of First-Year Available N&P in Manures

Manure	N:P ratio
Dairy	3.1
Beef	1.8
Poultry	2.5
Swine	3.8

Comparison of corn nutrient needs with manure nutrient content - Nitrogen strategy



Phosphorus in runoff from simulated rainfall applied to corn systems at Arlington, Wis., Sept. 1999

Location/ management	Soil test P	P in runoff	
		Soluble ,DRP	Total P
	---------- ppm ----------		
Chisel plow corn	17	0.04	4.2
No-till corn	11	0.03	3.2
Chisel plow + manure	38	0.07	3.0
No-till + manure	29	0.16	1.8

Phosphorus (P) and Environmental Concerns

- P losses from cropland can cause surface water quality problems.
- Soil P levels have increased.
- Manure P is a major contributor to soil P buildup.
- Land application of manure is often the only practical management option.